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AMENDED SPECIFICATION

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PATENT SPECIFICATION

Convention Date (France): Dec. 22, 1934. **451,557**

Application Date (in United Kingdom): Nov. 20, 1935. No. 32217/35.

Complete Specification Accepted: Aug. 7, 1936.

COMPLETE SPECIFICATION

New or Improved Method of and Means for Improving or Correcting the Acoustical Effects of a Room

We, ETABLISSEMENTS BERNARD ROUX, a body corporate incorporated under the laws of France, of 2, Rue Esquirol, Paris, France, (by whom the application for protection of the invention in France on the 22nd December 1934 was made and to whom the invention was assigned by the inventors BERNARD ROUX, MARIO SOLLIMA and ROBERT GAMZON), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a new or improved method of and means for improving or correcting the acoustical effects of a room, hall, studio or other enclosed space or auditorium by the use of a reverberation chamber or so-called echo room.

Architects have experienced great difficulty in producing rooms having good accoustic qualities, which latter must include not only good intelligible hearing of speech but also an agreeable colour or tone in the hearing of musical performances. This difficulty, which occurs with rooms or halls intended for direct audition, is greater in the case of sound studios wherein microphones pick up sound to be transmitted or recorded. With such studios, the fear of sound confusion resulting from echo has conduced to the employment of absorbent materials. These impart a dead and dull tone which is very disagreeable from the point of view of musical aesthetics.

Recent studies have shown that, once the echoes are avoided, the artistic sound quality of a hall or studio depends solely upon reverberation characteristics for the different musical frequencies. The reverberation period or time (this being the time during which the intensity of a simple sound, having its source of emission sharply arrested, falls to one millionth of its value) is not the same in one and the same room for all frequencies. It has been shown that a hall, having acoustics suitable for speech and music, should in certain cases have a greater reverberation period for deep and sharp or shrill sounds than for medium sounds. For the best effect, the reverberation period should vary as a function of the frequency following an optimum curve which, generally speaking, should be approached as closely as possible.

Moreover, this optimum curve varies according to the nature of the sounds. For example, it is not the same for an orchestra of wind instruments, an orchestra of stringed instruments, an organ and singing.

It is therefore desirable that this optimum curve should be modifiable at will in order to permit of the use of a single studio or of a single room for the audition or recording of concerts, recitals and the like.

When troublesome echoes have been avoided in a hall or studio by suitable architectural or acoustic arrangements, it is often found that the reverberation curve has no relation whatever to the optimum curve above mentioned.

The object of the present invention is to provide improved method and means for the regulatable correction or modification of the acoustical effects of a hall, room, or studio, thereby permitting of giving to an audience, without touching the form or nature of the walls, the impression of an acoustic property approaching the optimum curve aforesaid and variable at will.

According to this invention, an instal-

lation for modifying the acoustical effects of a hall, room, studio or the like comprises a reverberation chamber in a non-re-entrant circuit and regulatable means capable of acting selectively on the intensities of the several frequencies which traverse said circuit, in order to modify at will the relative intensity of certain of these frequencies or of certain bands of frequencies. If it is a matter of correcting or modifying the acoustical effects of a hall, room or other space in which an audience has direct hearing, the reverberated sound is returned by a system of amplifiers and loud speakers and is superimposed upon the sound emitted directly in the hall or the like. In the case of a sound studio, however, the reverberated sound may be mixed electrically with the sound normally picked up in such studio.

In carrying out the invention, one or more electrical filter devices is or are introduced into the reverberation chamber circuit for affecting the sound intensity corresponding to a given frequency or frequencies. In practice, the more general arrangement would include a filter or filters affecting the intensities of the sounds of different zones or bands of musical frequencies according to a given coefficient or coefficients of weakening regulatable at the will of the operator. The filters aforesaid may be introduced in the circuit from hall to reverberation chamber, or in the circuit from reverberation chamber to hall, or in the circuit from reverberation chamber to electrical mixer.

The total sound (direct sound plus reverberated sound)—or the equivalent modulations of electric current—then has, for each given frequency, a period of apparent reverberation which is greater as the aforesaid coefficient of weakening is less for that frequency. The maximum reverberation period, for a frequency or group of frequencies, is that of the reverberation chamber for that frequency or group of frequencies.

In practice, and for any given auditorium, it is possible to obtain a desired curve, as follows:—

(1) Take the real curve representing the reverberation period of the auditorium as a function of the frequency.

(2) Compare that curve with the curve that it is desired to obtain, for example, the optimum curve. (The problem can be resolved by this method only if the real curve does not present, for any frequency, a reverberation period greater than the corresponding period for the same frequency on the desired curve. This condition can always be realised by sufficiently deadening in its entirety the auditorium or studio concerned.)

(3) From the comparison is deduced the reverberation period that, for each given frequency or zone of frequencies, should be added to the natural reverberation period of the auditorium or studio for that frequency or zone of frequencies.

As already indicated, the required addition is obtained by means of a reverberation chamber and one or more filters, in a non-re-entrant circuit, the filters being adapted for giving to the appropriate frequency or group of frequencies the desired lengthening of the reverberation period.

The result of the foregoing intuitive reasoning can be made mathematically precise, as follows:—

Consider a reverberation curve giving sound intensity as a function of time for a given frequency, the origin of time being the arrest of sound emission from its source. The scale of intensity is linear for decibels and logarithmic for volts and the scale of time is linear. The curve of reverberation for a given frequency in the reverberation chamber is represented by a straight line A—B see Figure 4 of the accompanying drawings. The period of reverberation is O—B, the point O being 60 decibels beneath A. Let it be assumed, for simplicty, that the auditorium, for the frequency in question, has no reverberation, then, if the filters and amplifiers are regulated for giving no weakening to the transmission of the sound reverberated, the total period of reverberation will be O—B.

If, by regulation of the filters and amplifiers a weakening of, say, 10 decibels is effected in the sound reverberated at the frequency in question, the curve will be displaced 10 decibels parallel with itself and the total curve will be A—A[1]—B[1], the apparent period of reverberation being O—B[1] which is less than O—B.

The regulation of the weakening of the intensity for each frequency (a weakening that can be obtained and regulated by known means) determines therefore the apparent reverberation period for each frequency. In Figure 4, the reverberation period varies as the logarithm of the initial intensity of the sound reverberated.

If a weakening of 10 decibels is introduced in the circuit of the sound to be reverberated, the total period of reverberation is reduced only one sixth of its previous value. On the other hand, and with the same conditions, the sound passing through the reverberation system, being 10 decibels weaker than the direct sound, can be considered as negligible relatively to the latter. This shows that the reglation of the filters of a system in

accordance with the invention cannot, in practice, appreciably modify the curve of transmission of total resultant intensities from the initial source of sound to the sound recording or receiving apparatus, or to the ear of the audience. Its effect is manifested only upon the duration of reverberation.

The annexed drawings diagrammatically represent different examples of means for carrying out the invention.

Figures 1 and 2 are diagrams showing simple circuits leading to the reverberation chamber.

Figure 3 is a diagram showing a triple branch circuit leading to the reverberation chamber, and

Figure 4 is a diagram showing curves already referred to.

In Figures 1 to 3, S indicates an auditorium, hall, or sound studio, C is the reverberation chamber. In the auditorium, a microphone *m* produces electrical modulations corresponding to the sounds emitted. D is a device for deviating a part of the modulations on to a branch circuit ending in a loud speaker H in the reverberation chamber C. Electrical amplifiers are indicated at P1, P2, P3, P4 and P5, and the coefficient of amplification by these instruments may be regulatable or not.

In the chamber C a second microphone *n* picks up the sound reverberated in that chamber and introduces it to a mixer M where it is mixed with the sound transmitted directly from the microphone *m*.

In Figure 1 an electric filter F is placed between the microphone *n* and the mixer M for regulating the relation of the intensities for the different frequencies.

In Figure 2 a filter F1 is placed between the device D and the loud speaker H.

In Figure 3, the circuit from the device D comprises three branches each including a regulatable amplifier, as indicated at P1, P2, and P3. Each branch also includes a filter indicated at F*b*, F*m* and F*h*, and ends at a loud speaker in the chamber C, these loud speakers being indicated at H1, H2, and H3.

The three filters F*b*, F*m*, F*h*, are regulated so that each permits passage of an appropriate part of a sound. Thus, for example, the filter F*b* may be a low-pass filter permitting low tones to pass; the filter F*m* may be a band-pass filter for passing medium tones, and the filter F*h* may be a high-pass filter for the elevated tones.

The sound thus filtered is transmitted to the loud speakers H1, H2, H3. The acoustic mixture of sounds emitted by the loud speakers is reverberated in the chamber C and is then picked up by the microphone *n* and transmitted through the amplifier P4 to the mixer M. In this example, regulation of the reverberation curve can be accomplished by means of potentiometers, for instance, operating upon the amplification of the amplifiers P1, P2, P3.

The several examples relate to the case where the reverberated part of the transmission is mixed electrically with the part directly transmitted. Thus, they are concerned, more particularly, with the taking of records on discs, films and so on, or with the emissions of wireless telegraphy.

It is to be understood that analogous arrangements could be utilized for the transmission to an auditorium of the part reverberated only. In this case, the circuit of the microphone *n* would include one or several loud speakers placed in the auditorium at one or more suitable points.

Further, it is to be understood that the invention is not limited to the particular examples hereinbefore described and illustrated by the drawings. In particular, it is not necessary that both the transmission of sound to the reverberation chamber and the transmission of reverberated sound from that chamber, should be effected by electrical means. One of these transmissions could be effected by electrical means and the other by acoustic means. Of course, the means for varying the intensity of the sound reverberated as a function of the frequencies will be in that part of the transmission which is electrical.

We are aware of the prior patent specication No. 361,144 which relates to improvements in or relating to electrical sound transmission systems and discloses apparatus for simulating reverberation or echo effects comprising a delaying loop circuit which receives oscillatory current from the main transmission channel and is re-entrant, that is to say, it serves to feed back current, through a shaping network, to its own receiving point, so that current circulates in the closed loop circuit and fades away. The delayed oscillatory current in the loop is tapped off and is combined with current which has passed directly over the main channel. The frequency and phase characteristics of the circulating current are adjusted by means of the shaping network. The said specification also refers to an alternative arrangement utilizing in the loop an acoustic delay device comprising a loudspeaker and microphone arranged in an echo room. The present invention is to be understood to be limited to installations in which a non-re-entrant circuit is used and we disclaim any of the arrangements

described or claimed in the prior patent specification aforesaid.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Installation for modifying the acoustical effects of a hall, room, studio or the like comprising a reverberation chamber, in a non-re-entrant circuit, and regulatable means capable of acting selectively on the intensities of the several frequencies which traverse said circuit in order to modify at will the relative intensity of certain of these frequencies or of certain bands of frequencies.

2. Installation according to claim 1, further distinguished by the fact that sound is transmitted to the reverberation chamber through several electric circuits disposed in parallel and each containing a band filter and a device such as a potentiometer for regulating the intensity.

3. Installation according to claim 1 or claim 2, further distinguished by the fact that in the case of a hall, room or other space intended for direct audition and thus possessing reverberation effects of its own, the sounds obtained from the circuit containing the reverberation chamber are combined with the sounds reverberated in such hall, room or other space in order to obtain a total desired reverberation effect.

4. Installation for correcting or modifying sound emissions comprising a main transmission circuit, a non-re-entrant reverberation circuit including a reverberation chamber, and electrical devices comprised in the said circuits substantially as and for the purposes hereinbefore described with reference to the accompanying drawings.

Dated this 20th day of November, 1935.

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Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1939.

Fig. 1

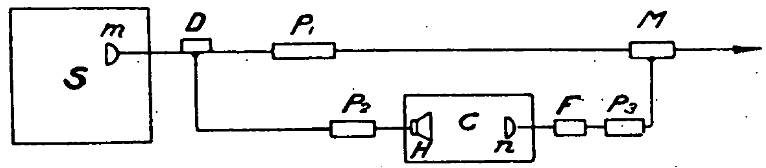


Fig. 2

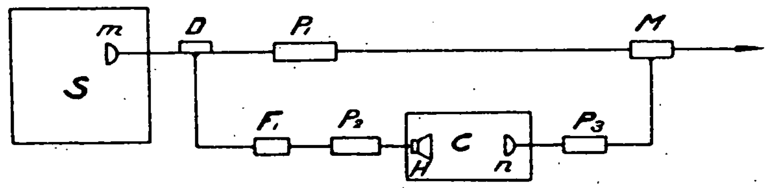


Fig. 3

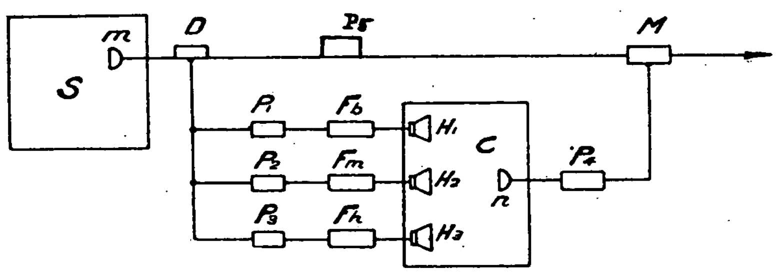
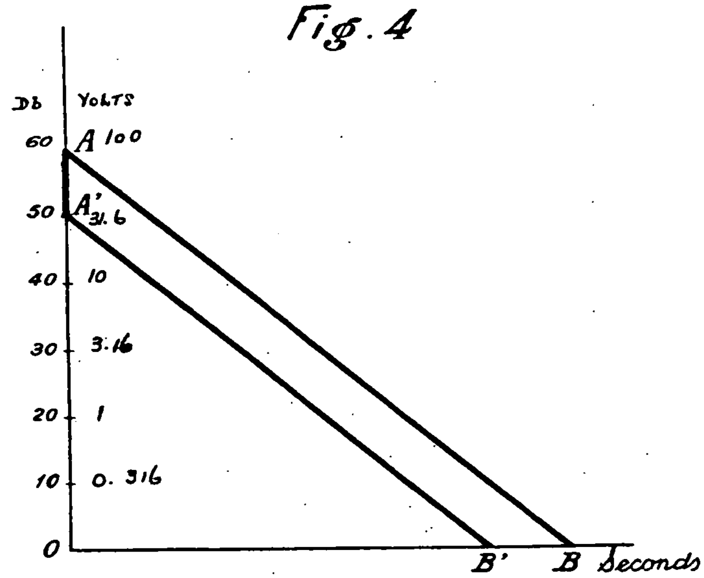


Fig. 4



[This Drawing is a reproduction of the Original on a reduced scale.]